BARÇA
INNOVATION HUB
Universitas

INJURIES AND TEAM SPORTS

PREVENTION

1.1 Definition of Injury and How It Influences Team Sports

It is difficult to prevent injuries from occurring in team sports, mostly due to their unpredictable nature. This is why a huge number of injury prevention programs have been studied and implemented over recent decades, in an effort to at least mitigate the number and severity of sports injuries.

These has brought about a need to classify the injuries and determine (or try to determine) what causes them. But first, we need to make something clear: athletes tend to suffer injuries whenever they expose themselves to situations for which they are not prepared, this means in terms of physical, psychological and nutritional preparation, among other factors. For example, if two soccer player players crash into each other when attempting to head a ball in a "second move," their ability to land in that situation will be fundamental in order to prevent an ankle or knee sprain, as well as to prevent muscle injuries upon the eccentric contraction that occurs upon making contact with the field of play.

Another case in which this applies is that the levels of force that an athlete is fit to support during an internal tibia rotation with the weight of their body resting on that same foot – which is in turn resting on the ground – will be inversely proportional to the severity of the anterior cruciate ligament (ACL) injury that they could suffer during this mechanism or motor pattern. Given that this represents that greatest percentage of ACL injuries. To be more precise, 70% of injuries to this ligament are suffered in situations that do not involve contact with the rival (Arendt E & Dick R 1995).

> In the case of handball in Scandinavian countries, 4 to 8% of players per year suffer ACL injuries, at a rate that is 3 to 5 times higher among women. (Engebretsen L & Bahr R, in Bahr & Maehlum 2007).
> In their study on ACL injuries among female athletes, Gray et al. explain that the most common injury mechanisms are resting on the foot while pivoting followed by a change of direction (29% of cases); landing a jump with the knee extended (28% of cases); abruptly landing a jump on one leg with hyperextension of the

knee (26% of cases). Another study that looks into mechanisms that can lead to ACL injuries in basketball and soccer establishes that the majority of injuries are caused without contact, especially following decelerations or jumping. (Romero Rodriguez D, in Romero & Tous 2011).

Turning our attention back to the need to classify possible causes of injury, the factors to consider when establishing this classification shall be: whether or not there was contact, the chronic, acute and immediate workload (at the exact moment of injury), the joint movement mechanisms in which it is caused (flexion, extension, abduction, rotation) the types of muscle contraction (concentric, eccentric, isometric), among other factors. And, of course, the combination thereof.

Romero (2011) classifies team sports injuries in two large groups:

- Traumatic injuries: Sprain, strain, contusion, fracture, dislocation, etc.
- Injuries due to overuse: this can be defined as any painful syndrome of the skeletal muscle system that appears without prior trauma or illness.

This is why, in order to be able to discuss prevention, we must first be familiar with the injuries and their incidence in sports. Van Mechelen (1992) proposes that, in order to be able to establish the incidence of injuries in sports, we must parameterize the number of injuries based on the length of exposure to a specific sport or discipline. However, this will only make sense if we first define what we mean by the term sports injury.

- Ekstrand (2009) refers to injuries, particularly in soccer, as the injuries that result from playing sports, which lead the player to be unable to fully participate in future training and competition.
- According to Bahr and Maehlum (2007) a sports injury is defined as a tissue damage caused as a result of participating in sports activities or physical exercise.
- Bahr and Trosshaug (2005), who take a biomechanical approach that considers the properties of the tissues and the characteristics of the load, consider an injury to be the result of a specific transfer of energy to tissue.
- Meanwhile, an injury can be classified as such if the player is forced to miss the entirety of the following game or training session. All events that lead to medical attention during competition or training sessions must also be considered as injuries. (Soomro et al. 2016)

- Gabbett (2004) defined an injury as pain or disability suffered by a player during training session or competition, which requires medical attention during or immediately after completing the session. He also classified injuries according to their severity, as temporary (without loss of training sessions), mild (loss of up to one week of training sessions), moderate (between two and four weeks of absence from training), serious (five weeks or more of absence from training).
- Van Mechelen (1992) proposes defining sports injuries as all types of damage that occur in relation to the practice of sports activities.
- Fuller (2006) performs a somewhat deeper analysis, characterizing sports injuries based on their consequences. Injuries for which the athlete requires medical attention are known as medical attention injuries. If the player is temporarily unable to compete as a result of their injury, this is known as a time loss injury.

This shows that the definitions of injury include damages, which, from a physiological point of view, are reflected in tissue ruptures, and from a sports point of view, mean a loss of performance, including the inability to participate in training and competition. This indicator shows us the direction in which the paradigms associated with injury prevention programs are oriented.

Injury incidence and characteristics.

When we talk about incidence, we must begin by mentioning the frequency with which injuries occur according to the specific discipline and level of competition. This is in addition to the level of exposure that an athlete faces when systematically playing the sport. As such, the number of injuries suffered for every specific number of hours that a specific sport is played shall be taken into consideration when analyzing the risk of injury faced by players. This is an extremely important exercise, firstly in order to establish the objectives that guide injury prevention programs, but also to be able to magnify the damages caused by injury, both financially and in terms of the sport itself.
According to Romero (2001), when calculating the number of hours of exposure to injury risk over a certain period, such as a season, we must include:

- The length of the match (1.5 hours)
- The number of players taking part in the event (in soccer this would be 22, 11 on each team)
- The number of matches played for each date of the tournament (10 games if the league has 20 teams)
- The number of dates that the tournament has. (38 dates if the tournament consists of two rounds, like the Spanish La Liga)

This will give us the number of hours of exposure to injury risk in a specific division or tournament. (1.5 x 22 x 10 x 38 = 12,540 hours).

Now, if we want to turn that number into an index (injury indices are generally calculated for every 1,000 hours of exposure), we must use a simple rule of three, considering the number of a specific type of injury, such as hamstring tears.

1,000 x number of tears / 12,540 = index of exposure to hamstring tears for every 1,000 hours of competition in the Spanish La Liga.

Table 1 shows an example of how to consider the injury exposure index (without differentiating by injury type) according to the discipline, using national teams as an example, both in competition and in training.

Table 1: Incidence of acute injuries in national teams.

Sport	During competition	During training
Basketball	2-3	5-6
Soccer	11-35	2-8

Handball	14	1-2
Ice hockey	29-79	1-3
Volleyball	3-6	1-4

Number of injuries for every 1,000 hours of participation.
Source: Taken from Bahr, R in Bahr R & Maelhum S (2007)

> In order to have an idea of the magnitude of the problem in the field of high level soccer, we know that around 9 injuries occur for every 1,000 hours of play (taking training and competition into consideration). (Cos F, Cos M, Buenaventura L, Pruna R, Ekstrand J 2010).

The number of hours and the exposure indices will be fundamental when it comes to considering the objectives of our prevention program. However, we must not forget to consider the severity of the injuries, that is to say, to consider which are the injuries that we really don't want our players to suffer. Keep in mind that each type of injury causes a performance loss that is qualitatively and quantitatively different. This is in addition to the cost of treatment for the injury as well as rehabilitation processes. And let's not forget the recovery time that each of them can imply. So, even though the muscle injury exposure index is greater than the anterior cruciate ligament injury exposure index, this does not mean that the prevention program will just be focused on the injury with the highest incidence rate, but also on those injuries that can cause the greatest damage, taking into account the aforementioned variables.

> Not all injuries are as serious in all sports, but it has been found that some team sports, such as basketball and handball, have a worryingly higher incidence rate of more serious injuries, anterior cruciate ligament injuries in particular (Bahr, R in Bahr R & Maelhum S 2007).

Another valuable way of considering the incidence of injuries in order to take preventive decisions is the method shown by Bahr (2007) (Table 2), which refers to the percentage that each sport or discipline can represent for a specific population or age group.

Table 2: Incidence and severity of sports injuries

	13 to 17 years old	18 to 24 years old	25 to 64 years old	Over 64 years old
Soccer	30	36	33	3
Handball	13	12	11	2

Volleyball	2	3	3	-
Basketball	8	5	1	2
Ball sports (unspecified)	7	6	6	4
Slalom/alpine skiing	5	6	5	1
Cross country skiing	2	3	20	40
Ski jumping	2	2	4	-
Ski mountaineering	3	2	2	1
Other ski sports including snowboarding	2	1	-	-
Skating	1	1	1	-
Ice hockey	2	2	1	-
Gymnastics/martial arts	8	9	4	9
Track and field	3	4	6	11
Rowing and water sports	2	1	2	3
Horse riding	3	1	1	1
Other	3	3	6	16
Unspecified	2	2	3	7
Total %	100	100	100	100

Source: Taken from Bahr, R in Bahr R & Maelhum S (2007).

Distribution of injuries in outpatients expressed in percentage (%) according to sport and age (n=244 thousand). The total of the percentages in the table will not necessarily be 100% due to the rounding of decimals.

Risk factors adapted to team sports

When we think about how to prevent injuries, in other words, how to prevent our players from suffering certain damage, or at least reducing the chances of this happening, we need to consider the characteristics of both the sport and of our athletes.

Risk factors are divided into extrinsic and intrinsic factors. The staff responsible for the health and performance of the team will undoubtedly have the greatest influence over those factors that depend on the player, and not what is beyond their control or what goes on around them. Therefore, the extrinsic risk factors

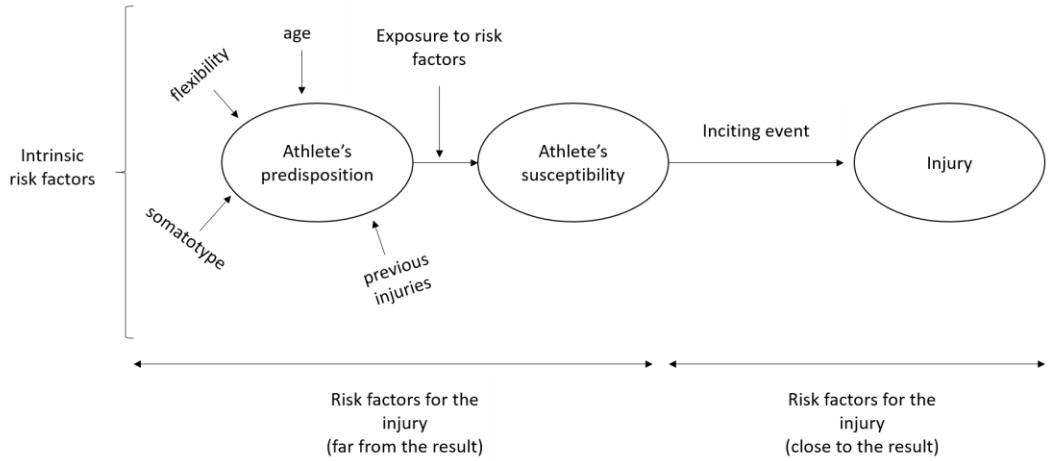
must be considered and taken into account, but the prevention program shall be developed based on the intrinsic risk factors, which are those that we have the most power to influence.

If we take the example of injuries caused by overuse, we need to understand that what is occurring is an imbalance between the capabilities of a subject to support a certain training load and the training load imposed on the subject. This tells us that, in addition to modifying the training load, our prevention program must also aim at increasing the capabilities of our athletes to resist the most frequent types of contact that occur in their given sport in order to reduce the incidence rate and severity of this type of injury.

As you can see, the injury risk factors are determined, on the one hand, by the force or stimulus applied on the player and, on the other hand, their ability to respond to them. Furthermore, training causes both positive and negative adaptations in the medium and long-term through the biological reactions in the individual (internal load) to an external stimulus proposed by the trainer or simply by the playing situation (external load). This is why injury prevention must be approached as a training process that aims to adapt the athletes' responses to game actions to which they will be exposed while playing sports and which pose an injury risk.

In fact, the two main objectives of monitoring the workload in team sports are, on the one hand, optimizing performance and, on the other hand, injury prevention by predicting their likelihood by recording acute and chronic load on the team and on the individual.
The risk factors must be considered as variables that interact among themselves to cause an injury. Above all, in team sports in which the predictability of the game situations is low. Cos et al. (2010) present a diagram of the multifactorial origin of injury in team sports created by Meeuwisse in 1994. This shows a combination of risk factors that increase an athlete's chances of suffering an injury, which will be expressed during the event that triggered the injury.

Figure 1: Model of multifactorial etiology in sports injuries.

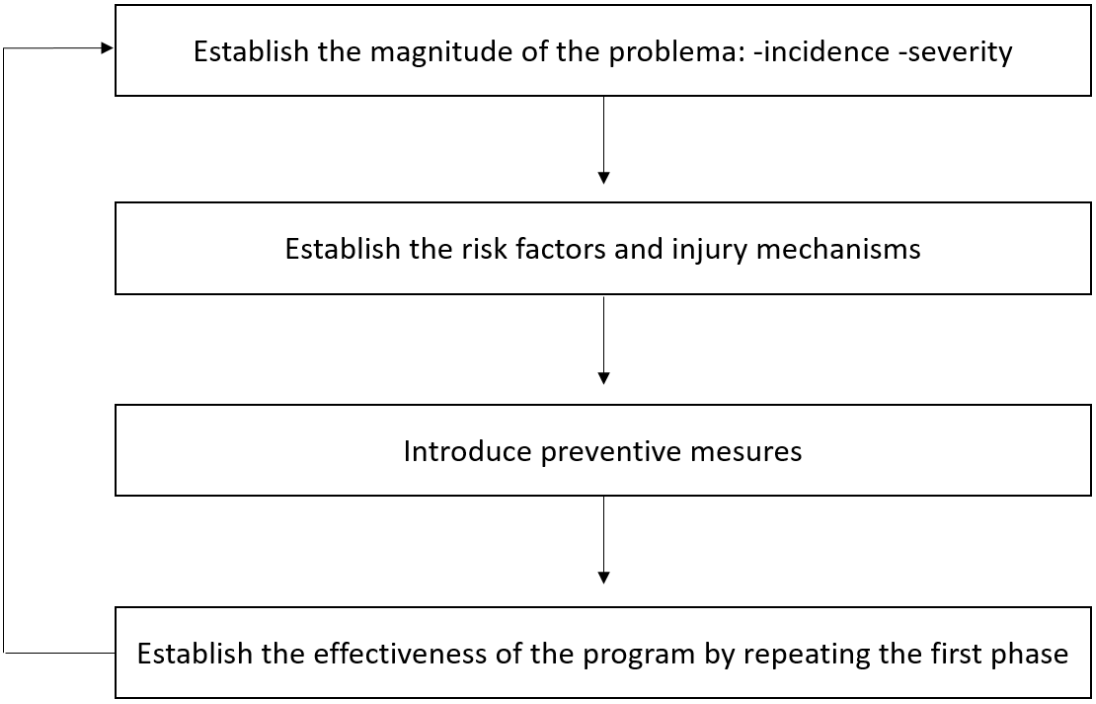


Source: Taken from Cos et al. (2010) (modified from Meeuwisse 1994)

Historic prevention models.

The injury prevention measures that we employ are not self-sustaining. On the contrary, they form part of a cycle, which is determined by a sequence. The first thing that must be determined is the magnitude of the problem, comparing the injury incidence rate with their severity. Next, the origins and mechanisms of an injury must be determined. Based on the foregoing points, the preventive measures are proposed and put into action. Lastly, it is necessary to study the effectiveness of the proposed measures, thus returning to the start of the cycle, applying the first step again, based on the results obtained (Van Mechelen 1992).

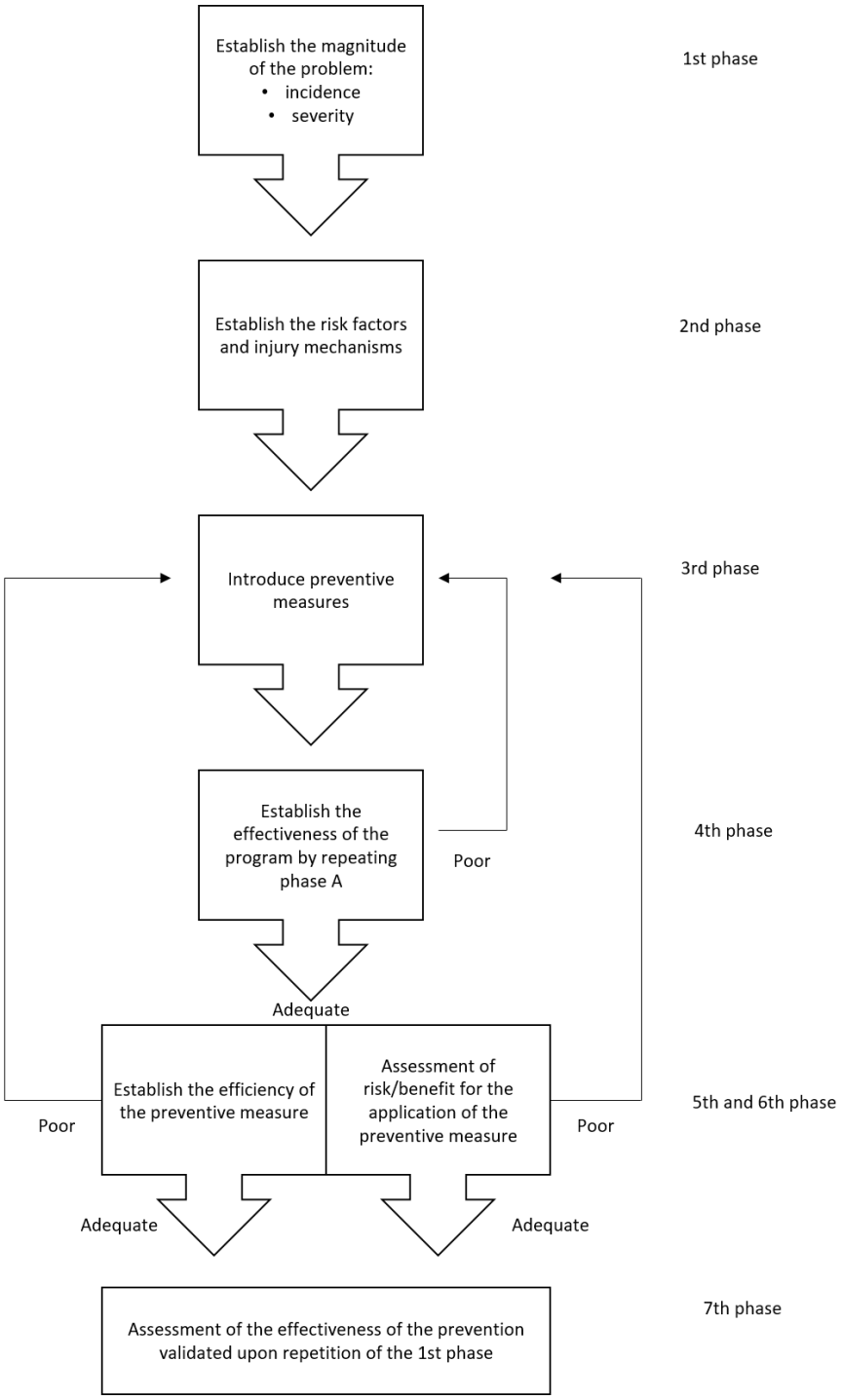
Figure 2: The sports injury "prevention sequence."



Source: Taken from Cos et al. (2010) (modified from Van Mechelen 1992).

This sequence has been used on a global scale and it is still a widely regarded model in terms of sports injury prevention. However, Van Tiggelen (2008) further develops this model, adding new steps to it. This includes considering, on the one hand, the efficiency of the proposed preventive measure, as well as its cost effectiveness. This is reflected in figure 3.

Figure 3: Van Tiggelen's model prevention sequence for repetitive sports injuries.



Source: Taken from Cos et al. (2010) (modified from Van Mechelen 2008)

Prevention program

The systematic use of an injury prevention program can reduce the injury index by up to 40% among young athletes. The exact reasons for this are still unclear. However, it is almost certainly due to increased strength levels, proprioceptive balance and flexibility. Increasing the athlete's overall state of physical readiness for playing sports. (Soomro 2016)

In some way, this demonstrates the importance of preventive intervention when it comes to mitigating the prevalence of injury in sport. However, as described above, we must bear in mind that said interventions must form part of a program that is tailored to suit the needs of the sport in general and of the athlete in particular. As such, below you will find some of the characteristics that must be considered in the design:

- Principles of injury prevention planning:
    - Multilaterality and polyvalence of the load: It is necessary to identify the most important physical qualities to be dealt with in order to reduce injury risk, as well as taking into account the technical and tactical abilities of the sport in question.
    - Specialization: The loads designed in a prevention plan must be specifically designed for each sports specialty. It is necessary to design tasks that are performed under conditions similar to competition conditions.
    - Individualization: The prevention must be adapted specifically to the athletes, to their most common technique-based pathologies, to their most defective movements, to improving their least-developed physical qualities and to the necessary metabolic requirements, among others.
    - The cyclic alternation or periodization must distribute the multilaterality of the loads over time. It is also necessary to systematically repeat said loads and their variations at variable time intervals. When it comes to prevention, it is necessary to study the adaptability of the prevention to the athlete's own training based on his or her athletic performance.
- Neuromuscular pillars of the prevention plan:
    - Perceptual-visual-vestibular system.
    - Strength understood as neuromuscular quality
    - Neuromuscular Coordination.

- (Romero D, in Romero, Tous 2011)

As such, it is essential to highlight the appearance of the cognitive component in prevention programs. This is due to the levels of constant uncertainty faced by the athlete in each playing situation in interactive sports that take place on a shared field such as basketball and soccer.

With this in mind, let's take a look at how, in the case of muscle injuries, the prevention program must cover the most frequent injury mechanisms that are due to the characteristics of each discipline. Below, we can see a clear example of this:

> The most common mechanism of muscle injury is eccentric contraction, i.e. the contraction of the muscle while lengthening. Just like in the case of fatigue or flexibility, the capacity for the tolerance of eccentric contraction is also trainable. If we take the example of hamstring injury prevention in soccer players, we see that teams that use specific eccentric hamstring training guidelines, such as the Nordic Hamstring Powers, achieve up to 65% fewer hamstring injuries than teams that do not use these guidelines.
> (Pedret Carballido C, & Rodas Font G, in Balius & Pedret 2013)

FC Barcelona Model

The club has two injury prevention levels: primary prevention and secondary prevention. The first consists of interventions that aim to prevent the initial appearance of injuries. Meanwhile, the second level is used to prevent or avoid injuries suffered in the past reappearing, taking into account that one of the most significant injury risk factors is the prior existence of injuries of this kind.

These processes do not necessarily have to be similar in the case of primary prevention, many of the tasks form part of the team training that takes place at times such as warm-up, or as part of the work done in the gym. The aim is to apply interventions that are designed not just to meet a certain objective, but which are based on the type of week and the team's current stage within competitions. This is in addition to individualized preventive work that arises from the detection of risk factors, the handling of which must be included in the primary prevention program. (Pruna R., Rodas G., Til L. 2015)

The preventive model considered relevant within FC Barcelona is based on the premise that the best method of prevention is proper training. It is well-known that sports in which the interaction with the space is shared are highly complex when it comes to intervening with so-called "preventive methodologies" (Romero D. en Seirul-lo F. 2017) meaning that it is vital to construct training tasks that aim to optimize and which allow the athlete to achieve a high level of participation during the entire competition calendar, i.e. spending as much time as possible with the coaching staff and their team mates.

As shown so far, the scientific studies related to injury prevention that are presented as tools for meeting the needs of all sports (in general) and athletes (in particular) often fail to make real proposals, in other words, they are not applied to real practice. This doesn't mean that these studies aren't valuable when used as a guide for achieving a better coadjuvant and optimizing process.

One of the questions that Romero asks (in Seirul-lo 2017) in relation to considering (re-considering) prevention in team sports is: how can we develop preventive action in this sports situation? (Referring to soccer as a shared-space sport where players struggle with each other for possession of the ball and face changing situations in which they need to switch into high velocities). This proposes an integrating approach in which the structures of each athlete (condition, coordination, cognitive, emotive-volitional and socio-affective) must be considered in order to "extend the athlete's athletic life."

In order words, what is the use of a "strong" athlete if he doesn't know how to use his strength in the situations that the game demands? What is the use of a "fast" athlete if she is never able to make the right decision? Do we need "resistant" athletes if the majority of their actions (a specific player) do not represent specific levels of aerobic capacity? All of these actions in which the athlete is trapped are highly important within the context of sport, and that is why training tasks must aim to preserve and respect a high degree of specificity so that strength, quickness and speed – among others – do not become actions that could potentially lead to injury.
Meanwhile, the stress generated before a big game (such as a final), or an unpleasant interaction between team mates, can lead to an athlete suffering an injury at a specific moment in the match. Similarly, the lack of tactical synchronization within a team can lead athletes to make decisions that compromise their health on the field of play; at the same time, unexpected changes of direction pose a high risk of injury in sports (both with and without

fatigue), for which reason it is fundamental to work (building favorable environments) on exercises in which the athlete achieves self-organization skills in order to make better decisions, allowing the athlete to economize effort and increase their motor quality.

In the 1980s, Paco Seirul-lo proposed the need to take an integrating approach to injury prevention and its inclusion in the training process.

Coadjuvant Training, suppressive training:
The objectives of this system are:

- - To continually improve basic coordination capabilities in areas of the body that are used the most heavily in the performance of the techniques specific to the sports specialty.
- - To achieve the necessary balance between the most important muscle groups, the protagonists and antagonists within the athlete's preferred techniques.

Years later, FC Barcelona has consolidated a new perspective that is based on the player's needs and the changing complexity of the game, re-defined as *optimizing-preventive training*.

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